**Course Description:**

This course covers advanced techniques in ecological modeling, including population dynamics, community modeling, spatial modeling, and ecosystem simulation. Students will build, analyze, and apply models to real-world ecological problems using statistical programming tools. Emphasis is placed on model construction, parameter estimation, sensitivity analysis, model validation, and uncertainty quantification.

**Course Objectives:**

By the end of the course, students will be able to:

* Develop and interpret deterministic and stochastic ecological models.
* Apply population, community, and ecosystem-level modeling approaches.
* Use spatially explicit and agent-based models.
* Calibrate, validate, and assess model uncertainty.
* Critically evaluate ecological models in scientific literature.
* Apply ecological modeling tools to inform conservation and management strategies.

**Prerequisites:**

Basic Ecology and Introductory Statistics; proficiency in R or Python recommended.

**Textbook (Recommended):**

* *A Primer of Ecological Modeling* by Karline Soetaert and Peter M.J. Herman
* *Modeling Population Dynamics* by Bruce Hannon and Matthias Ruth (optional supplementary)

**Software and Tools:**

* R (with packages: deSolve, nlme, mgcv, sp, raster)
* Python (optional; packages: SciPy, NumPy, Matplotlib)
* NetLogo (for Agent-Based Modeling)
* QGIS (for spatial model inputs/outputs)

**Weekly Topics:**

| **Week** | **Topics** |
| --- | --- |
| 1 | Introduction to Ecological Modeling: Scope and Importance |
| 2 | Review of Basic Models: Exponential and Logistic Growth |
| 3 | Structured Population Models: Matrix Models (Leslie, Lefkovitch) |
| 4 | Metapopulation and Source-Sink Models |
| 5 | Predator-Prey and Competition Models (Lotka-Volterra Systems) |
| 6 | Ecosystem Modeling and Biogeochemical Cycles |
| 7 | Stochastic Models and Uncertainty in Ecological Systems |
| 8 | Model Calibration and Validation Techniques |
| 9 | Spatially Explicit Models and Landscape Ecology |
| 10 | Introduction to Agent-Based Modeling |
| 11 | Species Distribution Models and Habitat Suitability |
| 12 | Sensitivity and Scenario Analysis |
| 13 | Applications in Conservation Biology and Climate Change Research |
| 14 | Student Model Presentations and Course Wrap-Up |

**Assessment:**

* Homework and Modeling Exercises (25%)
* Midterm Exam (20%)
* Final Modeling Project (35%)
* Final Exam (15%)
* Participation and Discussions (5%)

**Final Project:**

Students will select a real-world ecological problem, develop a model, calibrate it using real or simulated data, run sensitivity analyses, and present both a written report and an oral presentation.

**Course Policies:**

* Attendance and participation are expected, especially during discussions and presentations.
* Assignments must be submitted on time unless arrangements are made beforehand.
* Plagiarism or academic misconduct will result in disciplinary action.

**Important Dates:**

* Midterm Exam: Week 7
* Final Exam: Week 14
* Final Project Presentation: Week 13